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# Cognitive Trait Model for Persistent and Fine-Tuned Student Modelling In Adaptive Virtual Learning Environments

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## Abstract

The increasing need for individualised instructional in both academic and corporate training environment encourages the emergence and popularity of adaptivity in virtual learning environments (VLEs). Adaptivity can be applied in VLEs as adaptivity content presentation, which generates the learning content adaptively to suit the particular learner's aptitude, and as adaptive navigational control, which dynamically modifies the structure of the virtual learning environment presented to the learner in order to prevent overloading the learner's cognitive load.

Techniques for both adaptive content presentation and adaptive navigational control need to be integrated in a conceptual framework so their benefits can be synthesised to obtain a synergic result. Exploration space control (ESC) theory attempts to adjust the learning space, called exploration space, to allow the learners to reach an adequate amount of information that their cognitive load is not overloaded. Multiple presentation (MR) approach provides guidelines for the selection of multimedia objects for both the learning content presentation and as navigational links.

ESC is further formalised by including the consideration of individual learner's cognitive traits, which are the cognitive characteristics and abilities the learner relevant in the process of learning. Cognitive traits selected in the formalisation include working memory capacity, inductive reasoning skill, associative learning skill, and information processing speed. The formalisation attempts to formulate a guideline on how the learning content and navigational space should be adjusted in order to support a learner with a particular set of cognitive traits.

However, in order to support the provision of adaptivity, the learners and their activities in the VLEs need to be profiled; the profiling process is called student modelling. Student models nowadays can be categorised into state models, and process models. State models record learners' progress as states (e.g. learned, not learned), whereas a process model represents the learners in term of both the knowledge they learned in the domain, and the inference procedures they used for completing a process (task). State models and process models are both competence-

based, and they do not provide the information of an individual's cognitive abilities required by the formalisation of exploration space control. A new approach of student modelling is required, and this approach is called cognitive trait model (CTM).

The basis of CTM lies in the field of cognitive science. The process for the creation of CTM includes the following subtasks. The cognitive trait under inquiry is studied in order to find its indicative signs (e.g. sign A indicates high working memory capacity). The signs are called the manifests of the cognitive trait. Manifests are always in pairs, i.e. if manifest A indicates high working memory capacity, A's inverse, B, would indicate low working memory capacity. The manifests are then translated into implementation patterns which are observable patterns in the records of learner-system interaction. Implementation patterns are regarded as machine-recognisable manifests. The manifests are used to create nodes in a neural network like structure called individualised temperament network (ITN). Every node in the ITN has its weight that conditions and is conditioned by the overall result of the execution of ITN. The output of the ITN's execution is used to update the CTM.

A formative evaluation was carried out for a prototype created in this work. The positive results of the evaluation show the educational potential of the CTM approach. The current CTM only cater for the working memory capacity, in the future research more cognitive traits will be studied and included into the CTM.

# Table of Content

<b>CHAPTER 1: INTRODUCTION .....</b>	<b>1</b>
1.1: Custom Made Education.....	1
1.2: Thesis Layout .....	2
<b>CHAPTER 2: ADAPTIVE HYPERMEDIA SYSTEMS .....</b>	<b>7</b>
2.1: Introduction .....	7
2.2: Multimedia and Learning.....	7
2.3: Hypermedia.....	9
2.4: Adaptive Hypermedia .....	10
2.5: Summary .....	11
<b>CHAPTER 3: ADAPTIVE NAVIGATION .....</b>	<b>13</b>
3.1: Introduction .....	13
3.2: Navigational Support .....	13
3.3: Techniques for Adaptive Navigation .....	14
3.4: Summary .....	16
<b>CHAPTER 4: ADAPTIVE CONTENT PRESENTATION.....</b>	<b>17</b>
4.1: Introduction .....	17
4.2: Adaptive Content.....	17
4.3: Techniques of Adaptive Content Presentation .....	18
4.4: Summary .....	21
<b>CHAPTER 5: INTEGRATED THEORIES OF ADAPTIVITY .....</b>	<b>22</b>
5.1: Introduction .....	22
5.2: Multiple Representation Approach .....	22
5.2.1: Multimedia Object Selection .....	23
5.2.2: Navigational Object Selection .....	24
5.2.3: Integration of Multimedia Object .....	26
5.3: Exploration Space Control .....	28

<b>5.4: Summary .....</b>	<b>30</b>
<b>CHAPTER 6: EXPLORATION SPACE CONTROL FORMALISATION .....</b>	<b>31</b>
<b>6.1: Introduction .....</b>	<b>31</b>
<b>6.2: The Definition and Selection of Cognitive Traits .....</b>	<b>32</b>
<b>6.3: Exploration Space Control Elements.....</b>	<b>35</b>
<b>6.4: Working Memory Capacity .....</b>	<b>38</b>
6.4.1: Formalising with consideration of working memory .....	39
<b>6.5: Inductive Reasoning Skill .....</b>	<b>41</b>
6.5.1: Formalising with consideration of inductive reasoning skill.....	42
<b>6.6: Information Processing Speed.....</b>	<b>43</b>
6.6.1: Formalising with consideration of information processing speed .....	43
<b>6.7: Associative Learning Skill.....</b>	<b>45</b>
6.7.1: Formalising with consideration of associative learning skill.....	45
<b>6.8: Summary .....</b>	<b>47</b>
<b>CHAPTER 7: STUDENT MODEL .....</b>	<b>49</b>
<b>7.1: Introduction .....</b>	<b>49</b>
<b>7.2: Student Modelling.....</b>	<b>49</b>
<b>7.3: Application of Student Model.....</b>	<b>50</b>
<b>7.4: Modelling Competence State .....</b>	<b>52</b>
7.4.1: Overlay Student Model.....	53
7.4.2: Differential Student Model .....	54
7.4.3: Perturbation Student Model.....	54
7.4.4: Constraint-based Student Model.....	55
<b>7.5: Modelling the Process.....</b>	<b>55</b>
<b>7.6: Student Model Diagnosis.....</b>	<b>58</b>
7.6.1: Stereotypical Modelling.....	58
7.6.2: Coverage Measure .....	59
7.6.3: Performance Measure .....	60
7.6.4: Problem-solving State Tracing .....	60
7.6.5: Path Finding.....	61
7.6.6: Skill Tracing .....	61
7.6.7: Case-based Reasoning .....	61
7.6.8: Expert System .....	62
<b>7.7: Constructivism and Student Modelling.....</b>	<b>62</b>

7.8: Summary .....	64
<b>CHAPTER 8: COGNITIVE TRAIT MODEL .....</b>	<b>65</b>
8.1: Introduction .....	65
8.2: New Perspective for Student Modelling .....	65
8.3: New Approach for Student Modelling.....	66
8.4: Architecture For Incorporating Cognitive Trait Model .....	68
8.5: Summary .....	71
<b>CHAPTER 9: LEARNING OBJECTS AND RELATION-BASED BROWSING PATTERN ANALYSIS .....</b>	<b>72</b>
9.1: Introduction .....	72
9.2: Learning Objects .....	72
9.3: Navigational Pattern and Relation-Based Analysis.....	73
9.3.1: Content-less and Content-based Navigational Pattern Analysis.....	73
9.3.2: Relation-based Browsing Pattern Analysis.....	74
9.4: Learning Object Relations .....	75
9.5: Summary .....	80
<b>CHAPTER 10: TRAIT ANALYSIS .....</b>	<b>82</b>
10.1: Introduction .....	82
10.2: Trait Analyser .....	82
10.2.1: Structure of Trait Analyser .....	82
10.3: Analysis of Working Memory .....	84
10.4: Summary .....	88
<b>CHAPTER 11: MANIFESTS AND IMPLEMENTATION PATTERNS .....</b>	<b>89</b>
11.1: Introduction .....	89
11.2: Manifests.....	89
11.3: Implementation Patterns .....	91
11.3.1: Implementation Pattern for Navigational Linearity.....	92
11.3.2: Implementation Pattern for Reverse Navigation .....	94
11.3.3: Implementation Pattern for Excursions .....	97
11.3.4: Implementation Pattern for Simultaneous Tasks.....	98

11.3.5: Implementation Pattern for Retrieval of Information from Long-Term Memory .....	100
11.3.6: Implementation Pattern for Long Sequence of Calculation or Procedures .....	101
11.3.7: Other Manifests not Suitable for Implementation .....	102
<b>11.4: Summary .....</b>	<b>103</b>
<b>CHAPTER 12: INDIVIDUALISED TEMPERAMENT NETWORK .....</b>	<b>104</b>
12.1: Introduction .....	104
12.2: Individualised Temperament Network.....	104
12.3: Simulation for Selecting Appropriate Gradient Constant.....	108
12.4: Summary .....	116
<b>CHAPTER 13: PROTOTYPE WEB-BASED TUTORIAL WITH COGNITIVE TRAIT MODEL .....</b>	<b>117</b>
13.1: Introduction .....	117
13.2: Structure of the Domain.....	117
13.3: Description of the Tutorial.....	118
13.4: Technical Details of the Prototype .....	121
13.4.1: The Interface Module.....	121
13.4.2: The Student Behaviour History .....	122
13.4.3: The Trait Analyser .....	122
13.4.4: Student Performance Model .....	123
13.5: Example of Trait Analysis .....	123
13.5.1: Navigational Linearity .....	124
13.5.2: Reverse Navigation.....	125
13.5.3: Excursions.....	125
13.6: Formative Evaluation of the Prototype .....	128
13.6.1: Participants of the Evaluation .....	128
13.6.2: Evaluation Questionnaire and Summary .....	128
13.6.3: Discussion of the Evaluation .....	132
13.7: Summary .....	133
<b>CHAPTER 14: DISCUSSION AND FUTURE WORK .....</b>	<b>134</b>
14.1: Discussion .....	134
14.2: Future Improvement .....	135
<b>REFERENCES .....</b>	<b>138</b>



<b>APPENDIX 1: STATISTICAL RESULT OF THE SIMULATION .....</b>	<b>154</b>
<b>APPENDIX 2: EVALUATION OF COGNITIVE TRAIT MODEL.....</b>	<b>155</b>
<b>Brief Introduction to Concepts Used in This Evaluation .....</b>	<b>155</b>
<b>Introduction to the Prototype .....</b>	<b>155</b>
<b>Structure of the Domain (Optional for Evaluators to Fully Read this Section) .....</b>	<b>156</b>
<b>Brief Description of the Tutorial .....</b>	<b>157</b>
<b>Technical Details of the Prototype.....</b>	<b>160</b>
The Interface Module.....	160
The Student Behaviour History .....	161
The Trait Analyser .....	161
Student Performance Model .....	162
<b>Example of Trait Analysis (Optional for Evaluator).....</b>	<b>162</b>
Navigational Linearity (Optional for Evaluators).....	163
Reverse Navigation (Optional for Evaluators) .....	164
Excursions (Optional for Evaluators) .....	164
<b>Evaluation Questions - Cognitive Trait Model .....</b>	<b>167</b>